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# 古第三紀の砂岩・泥岩互層区間で発生した盤ぶくれとその対策

## ―九州新幹線（武雄温泉・長崎間） 久山トンネル―

鉄道・運輸機構 上村 将也

久山トンネルは九州新幹線（武雄温泉・長崎間）の諫早駅と長崎駅の間に位置する延長4,990mの新幹線複線断面の山岳トンネルである．地質は古第三紀の泥岩，砂岩・泥岩互層，砂岩および新第三紀および第四紀更新世の安山岩類からなる．久山トンネルでは，2019（平成31）年１月に一部の区間でインバート中央通路部に縦断方向のクラックおよび隆起を確認し，追加の地質調査を実施した．その結果，盤ぶくれの原因はインバート下部の水平方向の軸差応力が大きくなることで塑性変形するスクイージングであると推定した．これに伴い当初対策として，インバート下部方向へのロックボルトを施工し，水準測量などにより経過を観察していたが，対策を実施した範囲の一部の区間で変位の収束が微小ながら継続していたことから，追加対策としてグラウンドアンカーを施工した．本稿では，久山トンネルにおける盤ぶくれの発生状況およびそれに対する対策工の設計・施工と対策工の効果の検証結果について報告する．

**Heaving Occurring in the Paleogene Sandstone-Mudstone Alternation Section and Measures**

**―The Kyushu Shinkansen（Between Takeo-Onsen and Nagasaki）, the Kuyama Tunnel―**

**By Masaya Kamimura, Japan Railway, Construction, Transport and Technology Agency**

The Kuyama Tunnel is a 4,990 m long Shinkansen double track cross-section mountain tunnel located between Isahaya Station and Nagasaki Station on the Kyushu Shinkansen (between Takeo Onsen and Nagasaki). The geology is composed of Paleogene mudstone, sandstone-mudstone alternation, sandstone, and andesite of Neogene and Quaternary Pleistocene. Longitudinal cracks and uplifts were observed in the central passage of the invert in some sections of the Kuyama Tunnel in January 2019, and additional geological investigations were conducted. As a result, it was estimated that the cause of the heaving was squeezing which is plastic deformation caused by increased differential stress on the horizontal axial at the bottom of the invert. As an initial measure, rock bolts were installed toward the bottom of the invert, and the progress was confirmed by leveling and others. However, because the displacement continued to converge, albeit slightly, in some sections where the measures were taken, ground anchors were installed as an additional measure. In this paper, the authors report on the occurrence of heaving in the Kuyama Tunnel, the design and works of measures, and the results of verification of the effectiveness of the measures.

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# 対面通行切替により全幅一括でインバートを急速施工

## ―北陸自動車道 城山トンネル―

東日本高速道路（株） 増田 弘明

北陸自動車道城山トンネル下り線は，富山県の朝日IC～新潟県の親不知IC間に位置する1,578mのトンネルである．供用５年後の1993（平成５）年，路面隆起が確認され，変状対策工事としてマイクロパイルの打設を実施したものの，路面隆起が継続したことから，2020（令和２）年にリニューアルプロジェクトとしてインバートの設置工事（$L=491$m）を実施した．対策延長が長く，長期間の車線規制では社会的な影響が大きいことから，上り線に移動式コンクリート製防護柵による中央分離帯を設けて対面通行で運用し，下り線を通行止めとすることで，全幅一括施工によるインバートの急速施工を行った．本稿は，盤ぶくれの発生状況，施工計画検討，施工段階での創意工夫，および得られた成果と課題について報告する．

**Rapid Construction of Inverts over the Entire Width by Switching Two-Way Traffic**

**―The Hokuriku Expressway, the Shiroyama Tunnel―**

**By Hiroaki Masuda, East Nippon Expressway Company Limited**

The 1,578-meter long Shiroyama Tunnel on the Hokuriku Expressway is located between the Asahi IC in Toyama Prefecture and the Oyashirazu IC in Niigata Prefecture. In 1993, five years after the road was put into service, road surface uplift was confirmed. Although micropiles were installed as a measure for this deformation, the road surface continued to rise. An invert ($L=491$ m) was installed in 2020 as a renewal project. Because of the long time required by the project and the social impact of long-term lane closure, a median strip with a movable concrete barrier was installed on the upstream side of the road for two-way traffic, and the downstream side was closed to traffic to allow rapid construction of the invert by batch construction over the entire width of the road. In this paper, the authors report on the occurrence of the uplift, construction planning, creative ideas at the construction stage, and the results obtained and issues to be addressed.

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## 地すべり地帯でのレイズボーリング工法による立坑の施工

### ―滝坂地すべり　大石西山排水トンネル立坑―

国土交通省　山﨑　憲人

福島県の滝坂地すべりは日本最大級規模の地すべりであり，その地すべり対策の一環として排水トンネルの工事が進められている．この排水トンネルの終点部において通気立坑兼避難坑として，トンネル直上にある既設の集水井(深度36m)に接続する延長56.5mの立坑が計画された．立坑掘削は，レイズボーリング工法により排水トンネルから既設集水井底部までの55m間を直径φ1,750mmで行う計画であった．同工法による掘削後の孔壁は覆工の完了まで自立する必要がある．しかし，立坑は地すべりにより脆弱化した地盤を貫通するため，孔壁の自立性や地すべり面での出水に伴う土砂の流出など施工時の安全性が懸念された．このため，既設集水井をセグメント方式によりすべり面まで23m延伸し，その下方の脆弱な地盤については地盤改良により強度を高めて掘削を行った．本工事は，設計段階から施工業者が関与する「技術提案・交渉方式」(ECI方式)による発注であり，本稿では，技術協力業務での立坑の掘削工法や構造変更の技術提案，立坑の施工について報告する．

### Construction of a Shaft Using the Raise Boring Method in a Landslide Area
### ―Takisaka Landslide, the Oishi-Nishiyama Drainage Tunnel―

By Norihito Yamazaki, Ministry of Land, Infrastructure, Transport and Tourism

The Takisaka Landslide in Fukushima prefecture is one of the largest landslides in Japan. A drainage tunnel is being constructed as a part of the landslide measures. At the end of the drainage tunnel, a 56.5-meter long shaft was planned to connect to an existing water catchment well (depth 36 m) located directly above the tunnel as a ventilation shaft and evacuation tunnel. The shaft between the drainage tunnel and the bottom of the existing water catchment well was planned to be excavated using the raise boring method. The diameter of the shaft is 1,750 mm, and the excavation distance is 55 m. After excavation using this method, the borehole wall must be self-supporting until the lining is completed. However, because the shaft penetrates through the ground weakened by the landslide, there were concerns about safety during construction, such as the self-support of the borehole walls and the discharge of earth and sand due to water flow on the slip surface. The existing water catchment well was extended 23 m to the slip surface using lining segments, and the weak ground below the well was strengthened by ground improvement and excavated. This project was ordered by the “Technical proposal and negotiation method” (ECI method), in which the contractor is involved from the design phase. In this paper, the authors report on the technical proposal for the excavation method and change of the shaft structure, and the construction of the shaft as part of the technical cooperation work.

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## 立坑用地のない都市部で先行シールド内から分岐シールドを発進

### ―福岡市下水道　天神周辺地区雨水整備事業―

福岡市　原之園雅光

九州経済の中心地である福岡市は，1999(平成11)年および2007(平成19)年の梅雨前線による豪雨により，都心部である天神周辺地区が２度にわたり甚大な浸水被害を受けた．このため，浸水対策の計画として「雨水整備レインボープラン天神」を策定し，全国的にも高い雨水整備水準である１時間79.5mmの降雨に対応する下水道施設整備を進めている．本稿では，泥土圧シールド工法による２路線の雨水管渠の築造において，都市部における土地利用の制約により立坑用地の確保が困難であったことから採用した分岐シールド工法の施工実績について報告する．

### Launching a Branch Shield TBM From within the Preceding Shield Tunnel in an Urban Area Where There Is No Land for a Shaft
### ―The Fukuoka City Sewerage, Around Tenjin area the Rainwater Improvement Project―

By Masamitu Haranosono, Fukuoka City

Fukuoka City, the center of Kyushu’s economy, was severely inundated twice in the around Tenjin area, the heart of the city, in 1999 and 2007 by torrential rains caused by a seasonal rain front. For this reason, the “Rainwater Improvement, Rainbow Plan Tenjin” for inundation control was formulated, and sewerage facilities are being improved to cope with rainfall of 79.5 mm per hour, which is a national high level for rainwater improvement. In this paper, the authors report on the construction results of two rainwater conduits using the muddy soil pressure balanced shield tunneling method, which was adopted because it was difficult to secure a shaft site due to land use restrictions in an urban area.

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# 共同溝の直下を730mにわたり近接する急曲線小口径シールドの施工

## ―東京電力 つつじヶ丘洞道―

東京電力パワーグリッド(株) 森本 陽介

東京電力パワーグリッド(株)では，電力安定供給のための経年対策として基幹系地中送電ケーブルの計画的な引替えを行っている．この対策の一環として数十kmにわたり直接埋設された地中ケーブルの共同溝などへの移設を計画している．本工事は，このうち共同溝内へのケーブル冷却設備の導入などのための単独洞道工事であり，新設の調整所から国道20号の共同溝までの980mの区間を内径2.40mのシールドトンネルで連係するものである．本稿では最小曲線半径15mを含むトンネルのルート選定，シールド工法選定，覆工設計，および共同溝の直下を縦断方向に約730m近接する急曲線小口径の泥土圧式シールド工法の施工などについて報告する．

## Construction of a Steeply Curving Small Diameter Shield Extending for 730 m under a Utility Tunnel

## ―TEPCO Tsutsujigaoka Power Cable Tunnel―

By Yosuke Morimoto, TEPCO Power Grid, Incorporated

TEPCO Power Grid, Incorporated is systematically replacing its trunk underground power transmission cables to ensure a stable supply of electricity as an aging measure. Relocation of underground cables that have been directly buried for tens of kilometers to utility tunnels is planned as a part of this activity. This project includes the construction of an independent tunnel for the installation of a cable cooling system in a utility tunnel. A shield tunneling with an inner diameter of 2.40 m is used to connect the 980 m section from the newly constructed control station to the utility tunnel on National Route No. 20. In this paper, the authors report on the route selection, shield tunneling method selection, lining design, and construction of a steeply curving, small-diameter shield tunnel with a minimum curve radius of 15 m which is located approximately 730 m in longitudinal direction directly under the utility tunnel.